Life Sciences Centrifuge Facility

Assessment - Final Report

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LIFE SCIENCES CENTRIFUGE FACILITY ASSESSMENT

I. INTRODUCTION

A review of the Centrifuge Facility was conducted at the Ames Research Center (ARC) on August 30 through September 1, 1994. The review team consisted of both NASA field center civil service personnel and external consultants. The review included a wrap-up session where discussions and inputs were provided by the review team members for an interim report on the project status to the Office of Life and Microgravity Sciences and Applications (OLMSA) at NASA Headquarters. The review at ARC included all aspects of the project including science objectives, performance requirements, technical progress, project schedules, project budgets, and management. Risks and issues to the project were identified and recommendations formulated to aid in their resolution.

II. ASSESSMENT OF SCIENCE REQUIREMENTS (MATURITY AND PLANNING)

The science requirements for the Centrifuge Facility have been in work for about a ten-year period. A science working group composed of knowledgeable and active investigators has been utilized since 1985 in formulation of these science requirements and in review of the translation of these science requirements into engineering specifications for the design and development of the Centrifuge Facility. A Level I and Level II set of science requirements are documented and are managed under appropriate control boards. The planning and maturity of these requirements are derived from a long history of ground-based research as well as flight experience on both U.S. and Russian spacecraft. The science requirements appear to be both reasonable and attainable by the Centrifuge Facility planned for operations on the International Space Station Alpha (ISSA). Selection of the actual science experiments and principal investigators, that will utilize the Centrifuge Facility, will be at some future date, on the order of two years prior to launch of the Centrifuge Facility. This area within the project is well defined and is very mature relative to the projected development schedule for the Centrifuge Facility.

III. ASSESSMENT OF THE PERFORMANCE REQUIREMENTS

The performance requirements on the Centrifuge Facility are well understood and do not appear to represent major technology challenges. Similar performance requirements have been achieved on previous U.S. flights relative to animal and plant holding facilities and relative to a glovebox work station. The performance requirements on the Centrifuge itself have been reduced during the past six months which significantly simplifies the presently planned performance and operations of the Centrifuge.

A. Definition Phase Studies

The project has been through a number of Phase A and Phase B definition studies both in-house and with contracted efforts. These studies have provided a strong technical basis for the presently planned Centrifuge Facility. The presently planned Centrifuge Facility includes a number of hardware elements: the centrifuge itself, two habitat holding racks for accommodating both plants and animals, plant research units, advanced animal habitats, a life sciences glovebox, general laboratory support equipment, service system rack, refrigerators, freezers, and general stowage racks. While all of these hardware elements are required to conduct science with the Centrifuge Facility, some of these hardware elements are being provided to the project from other sources. Until recently, the ISSA was providing the glovebox and lab support equipment. The responsibility for their development has recently been transferred to OLMSA, and it would appear reasonable that their development be included in the Centrifuge Facility Project.

The plant research units, the advanced animal habitats, and a biotelemetry system that will be a subsystem in a number of the hardware elements are being provided to the Centrifuge Facility Project by other ARC organizational elements. In addition, the refrigerators, freezers, and some general lab support equipment will be provided by ISSA. There is some concern over how the project will acquire a service rack and stowage racks needed for its on-orbit operations. A logical assumption would be that ISSA would provide these basic racks; however, formal agreements between the Centrifuge Facility Project and ISSA have not been made.

In addition to a number of definition studies performed to date, several test beds have been developed which add credence to the assessment that the performance requirements can indeed be met. As previously noted, the Science Working Group has

reviewed and concurred in the present set of performance requirements for the Centrifuge Facility.

B. Interface Documentation Maturity

Interface documentation requirements are well understood by the project. Those interface documents internal to ARC organizations supporting the Centrifuge Facility Project are reasonably mature. However, interface documentation external to the project, particularly with ISSA, need program level decisions before they can be updated. One major concern is where the Centrifuge Facility will be accommodated on the ISSA. The most viable options appear to be in some sort of module. Either an additional U.S. lab, a payload logistics module modified to meet the Centrifuge Facility requirements, or a possible Spacehab configuration. The Spacehab configuration could have the most significant impacts for accommodation of the Centrifuge Facility, even to the extent of reducing its size from its present 2.5 meter diameter. Program level decisions need to be made as soon as possible to ensure appropriate interfaces can be defined prior to the project starting its contracted C/D phase. In addition, there is an interface incompatibility in the design planned for numerous elements of the Centrifuge Facility and the International Standard Payload Rack (ISPR). The project is planning to utilize a Standard Interface Rack (SIR) set of hardware, which has been flight demonstrated and which allows life sciences hardware elements to fly in the Shuttle middeck on Spacelab or on ISSA without mounting modifications. Agreements need to be made on this interface issue with ISSA, which will provide for SIR interfaces allowing maximum flexibility for accommodating life sciences experiments on all of these carrier systems. This may also require a program level decision.

Other interface agreements appear to be well understood and in-hand.

IV. ASSESSMENT OF FACILITY COST AND SCHEDULES

The Centrifuge Facility Project has significant in-house and Phase B contractor information relative to the total cost associated with the project. There have been numerous perturbations; however, which have and may affect budget profiles in the future. The project was rebaselined during the past six months, which simplified the overall design of the Centrifuge and which allowed for earlier development of various hardware elements

and reduced overall costs. However, since that time, the project was requested to take on the development of a biotelemetry system utilized in several of the hardware elements, to fund the development of a service rack, and to provide budgeting, planning and conduct of three verification flights on the ISSA to verify that the various Centrifuge Facility hardware will operate as designed and to verify viable science can be conducted in this Centrifuge Facility. This places a severe strain on the early year budgets (FY-96 through FY-98) in that both center reserves and Headquarters APA were proposed to solve the shortfall. Since that time, responsibility for the Life Sciences Glovebox and lab support equipment has been transferred to the OLMSA from ISSA without any budget transfers. In addition, the funding for two elements within the transferred lab support equipment line have yet to have cost estimates. There is also an estimate of $4M for payload to rack analytical integration that does not appear to be budgeted by ISSA which also may be transferred to OLMSA. The development of several of these items are critical to the Centrifuge Facility and funding must be provided. Some relief to these funding issues may be viable from within the project. The project was requested to review the design and development schedules possibly to allow some of the hardware to be developed in series versus presently shown parallel development. The amount of design schedule for both the Centrifuge and the Glovebox appear longer than necessary which could allow placing these elements more in series development. In addition, the project has had to make assumptions on the operations of the Centrifuge Facility on-orbit, which in turn drove requirements for additional hardware to support these operations. OLMSA needs to provide the project with guidance on how often and for what length of time the Centrifuge Facility can be expected to operate on the ISSA. This may reduce some of the additional pieces of hardware elements presently in the proposed baseline. During this review, the project also was requested to make a trade study on the need to procure a centrifuge model for use in neutral buoyancy training, should it become necessary to disassemble the Centrifuge on-orbit and return it to ground for refurbishment. The design requirements on the Centrifuge require this capability. Since disassembly and reassembly would be an Intra-Vehicular Activity (IVA) versus an Extra-Vehicular Activity (EVA), the need for the neutral buoyancy training model was questioned.

Although adjustments to the schedules may need to be made, the time identified for the design and development schedules appear viable to meet delivery dates for projected launches of the various hardware elements.

V. ASSESSMENT OF PROGRAMMATIC RISK

Programmatic risk from science, performance, and schedule are moderate to low. However, there is programmatic risk unless a firm commitment to where and how the Centrifuge will be accommodated is made in the next several months. In addition, unless additional funding is provided to the project, to cover the additional responsibilities for hardware transferred from ISSA and which are required to carry out the program, a significant programmatic risk will be incurred.

VI. OTHER ISSUES OF IMPORTANCE IDENTIFIED DURING THE REVIEW

A significant aid to the planning for all the OLMSA's ISSA facilities would be Level I guidance on expected on-orbit operation scenarios. How often and how long each of these facilities can be expected to operate will aid in determining the amount of hardware required to carry out the science programs. In addition, OLMSA needs to review their facilities requirements on Space Station relative to station resources (i.e., power, thermal, crew time, data rates, stowage on-orbit, etc.). The operational scenario shown for the Centrifuge Facility could require up to seven or eight on-orbit storage racks which in turn map into 8-9 racks required for logistics flights to and from ISSA. In addition, up to seven cubic feet of refrigerator/freezer volume would also be required. More realistic operational scenarios also would reduce these requirements. The operational scenario shown for the Centrifuge Facility will have a major impact on any other payloads wanting to operate at the same time because of the large power and thermal requirements. An integrated systems look by OLMSA across all its planned facilities should be performed in the near future to provide guidance to the project development organizations. Such an integrated systems look could possibly identify common hardware subsystems which, if these common subsystems could somehow be utilized in all the facilities in development, may reduce both facility development costs and sparing costs. An item related to this, which created significant problems during the early Spacelab years, was the procuring and sparing of fasteners and

connectors. Some of the lessons learned during the early Spacelab years are very appropriate to these development projects and should be reviewed. In fact, if some standardized fasteners and connectors could be agreed upon, the inventories maintained for these small but critically important items could possibly be transitioned from Spacelab inventories to Space Station.

VII. SUMMARY

The project is well staffed with experienced personnel in all areas - project management, control, systems engineering, ground and flight operations, science and discipline engineering. The project office should be well able to manage the designs and development of the Centrifuge Facility. The experienced staff, in addition to the extended period that this project has been on-going, will minimize the programmatic and technical risks and should provide for a successful program. However, program level decisions need to be made as soon as possible in several key areas to ensure programmatic risks remain small. These program level decisions include:

- Identifying where on the Space Station the Centrifuge Facility will be accommodated.

- Making available Space Station racks to the facility projects which meet the Standard Interface Rack configuration.

- Providing guidance on realistic operational scenarios for the Centrifuge Facility while on-orbit.

- Providing additional funding to cover all hardware required to operate the Centrifuge Facility effectively (i.e., glovebox, lab support equipment, etc.).

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This report provides an assessment of the status of the Centrifuge Facility being developed by the Ames Research Center for flight on the International Space Station Alpha. The assessment includes technical status, schedules, budgets, project management, performance of facility relative to science requirements, and identifies risks and issues that need to be considered in future development activities.

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